measuring apparatus, and it is to be hoped that all Weather Bureau observers will see to it that both apparatus and methods are so correct that an error of 1 per cent can not occur systematically.

A copy of the Editor's article "On the determination of the true amount of precipitation and its bearing on theories of forest influences" can be furnished to any observer who desires it.

The large differences between adjacent gages are usually due chiefly to wind effects. Two similar gages set on posts in an open field, the mouths being elevated above ground 1 or 2 and 4, 5, or 6 feet, respectively, give the data for determining approximately the correction to the lower gage, so as to get results approximately free from the wind effect.

If the altitudes are H_1 and H_2 and the corresponding catches C_1 and C_2, then the the true rainfall is approximately

$$R = C_1 + \frac{\sqrt{H_1}}{\sqrt{H_2}-\sqrt{H_1}}(c_1-c_2) = C_1 + \frac{1}{\sqrt{\frac{H_2}{H_1}}-1}(c_1-c_2).$$

Example: $C_1 = 25.50$ inches for $H_1 = 2$ feet, and $C_2 = 23.00$ inches for $H_2 = 6$ feet. Then will $R = 25.50 + 1.366 \times 2.50 = 28.91$. In other words, the lower rain gage, 2 feet above the ground, catches only 88 per cent of what would be caught by a pit gage at the surface of the ground in calm weather. This corresponds to an annual rainfall in the drier portions of our country and to strong winds or small raindrops. When every individual rainfall through the year has been computed in this manner, it may be possible to arrange the deficits in the order of the observed general velocity of the wind and determine the specific influence of feeble and strong winds on small or large raindrops and on snows, and on protected gages as distinguished from those that are freely exposed to the wind.

SEISMOGRAPH STATIONS IN THE UNITED STATES.

We are informed that in 1889, Mr. A. Lawrence Rotch, the distinguished patron of meteorology, purchased and set up at the Blue Hill Observatory, a Ewing-Holden seismograph, as made in San Francisco. During the first year that the instrument was maintained in working order no records were obtained. Recently the Massachusetts Institute of Technology has built a geodetic observatory for educational purposes, in the Middlesex Fells, north of Boston, in an isolated situation, and Mr. Rotch has given his seismograph to the Institute, so that it will now be installed at the new observatory within a few months. A description of this observatory is published in the Technology Quarterly for June, 1899.

We hope that this augurs well for regular seismological work in the United States, a matter that has been much neglected, except possibly in California.

It has always been the custom for meteorological observers, especially those of the Smithsonian system, to record the occurrence of earthquakes. In 1874, the present Editor, in reorganizing and extending the field of the MONTHLY WEATHER REVIEW began the regular publication of earthquake notes, so far as observations were received, and, in 1883, at his request, a joint committee on earthquakes was organized in Washington, by cooperation with the Coast Survey and Geological Survey.

This whole subject is a branch of geo-physics, coordinate with the study of vulcanology, surface geology, meteorology, tides, etc., and is worthy of special recognition. It is to be hoped that the article on the Milne seismograph, published in the MONTHLY WEATHER REVIEW for May, will revive active interest in the subject.

At present the only stations in the United States that are known to keep seismographs of any kind in continuous operation ready for any earthquake that may occur, are the following seven: Washington, D. C., (Weather Bureau, Marvin seismoscope); Middlesex Fells, Mass., (one mile from Malden, Geodetic Observatory, Ewing-Holden seismograph); Cleveland, Ohio, (Prof. E. W. Morley, Adelbert College, Gray seismograph); Lick Observatory, Cal., (Mount Hamilton, Ewing-Holden seismograph); San Francisco, Cal. (Observatory of the Coast and Geodetic Survey, G. W. Davidson, Director, Ewing-Holden seismograph); Mare Island, Cal., (Naval Observatory, Everett Hayden, Superintendent, Ewing-Holden seismograph; latitude, 38° 05′ 55.8″ N.; longitude, 122° 16′ 19.3″ W., on the crest of a hill about 60 feet above mean low water and near the northern extremity of the island; the seismograph is set up on a pier in the transit room); Oakland, Cal., (Chabot Observatory, Professor Burchalter, Ewing-Holden seismograph).

Prof. E. C. Pickering states that a Milne seismograph has been sent by him to his observatory at Arequipa, Peru, and is probably now in operation there. There are also seismoscopes on hand at the Harvard College Observatory at Cambridge, Mass., but they are not in use owing to the proximity of the electric cars.

As the vibrations of the ground caused by the electric cars are quite superficial we hope that Professor Pickering will find a suitable location for observing the genuine earth tremors and that all these stations will kindly send regular reports to the MONTHLY WEATHER REVIEW.

BACK NUMBERS.

Mr. A. Lawrence Rotch, Director of the Blue Hill Meteorological Observatory (post office Hyde Park, Mass.), desires to obtain the following numbers of the American Meteorological Journal, viz: June, July, and August, 1884, of Vol. I; June and July, 1885, Vol. II; September, October, and December, 1886, Vol. III.

TEMPERATURES IN THE SUNSHINE.

In the June report of the Colorado section, Mr. F. H. Brandenburg gives a summary of some observations made at Denver, Colo., by Mr. A. G. Eneas, of Boston, Mass. Mr. Eneas used standard thermometers with black bulbs, placed within a so-called hot box, which was constructed of seasoned pine wood five-eighths of an inch thick. Its dimensions were 9 by 3.5 by 2 inches. The cover was made of two plates of fine crystal plate glass. The inside of the box was stained with bright green water-color paint and then coated $\frac{1}{32}$ of an inch thick with lamp black. The same apparatus had been used by Mr. Eneas in Boston before he made a series of observations for several months at Denver. The greatest difference observed at Boston between the outside air temperature and the interior hot-box temperature was 40° C., or 90° F. The similar maximum difference at Denver was 98.5° F. This excess may be largely due to the pure air of Colorado or it may be due to various nonmeteorological causes. Such observations are not to be recommended, since it is so easy to do better work.

This form of hot box is one of several methods of illustrating, not measuring, the total radiation of the sun by means of its heating effects. The best form of hot box was that invented by Pouillet, more properly called the pyrheliometer, and was filled with water, which was continually stirred, so that the total amount of heating effect could be more certainly measured by the thermometer. But such apparatus

does not give us a true measure of the amount of heat received from the sun, or of the transparency of the atmosphere, unless it be used in the proper manner. If we merely allow the temperature of any inclosed thermometer to rise to the highest point it can reach, we observe maximum temperatures that depend so entirely upon the peculiarities of the hot box itself and of the wind that happens to be blowing, that no important results can be attained.

The hot box first used by Herschel, de Saussure, and other physicists of the last century, was early in this century replaced by Sir John Herschel's form of the actinometer and, subsequently, by the so-called black-bulb thermometer, which latter was improved by inclosing it in a thin spherical glass bulb inclosing a vacuum. To Arago we owe the addition of the twin black-bulb thermometer in vacuo. For a long time, and even now by English makers, the maximum self-registering thermometer was used, but in the properly constructed system devised by Marie Davy, and now known throughout the world as the Arago-Davy actinometer, both thermometers are delicate, spherical-bulb thermometers, of high grade of accuracy. The ordinary method of using this instrument is to take a series of readings when the two thermometers are exposed side by side in the open sunshine and have attained to comparatively stationary readings. The complete theory of this instrument and the proper method of calculating the results are fully given in the third section of Prof. William Ferrel's memoir Temperature of the Atmosphere and Earth's Surface, published in 1884 as No. XIII of the Professional Papers of the Signal Service. Each of the twin thermometers in vacuo attains a stationary reading when the heat received by radiation, absorption, and conduction equals that carried away by radiation and conduction. Since the two thermometers have surfaces of different absorptive powers and, therefore, different coefficients of reflection and radiation, the sunshine effects each differently, and we can, by considering a series of observations at different hours of the day, determine at once the amount of absorption of the atmosphere and the intensity of the sunshine.

In 1883 the Editor constructed and experimented with an Arago-Davy actinometer in which the thermometers were alternately shaded and exposed. Similar apparatus was taken to Russia by Mr. Rotch for use during the total solar eclipse. The same principle is embodied in Angström's and Chwolson's forms of the pyrheliometer which are described in an article by Chwolson, pages 71–75 of Bulletin No. 11, Report of the Chicago Meteorological Congress of 1893, to which the reader is referred for further details. The Arago-Davy, or the Pouillet apparatus, when properly used, gives crude approximations, but the Chwolson method gives fairly accurate results. The works of Crova, Angström, Chwolson, and Ferrel are to be commended to those who have the requisite skill in experimentation.

DESTRUCTIVE FROST OF JUNE 30, 1899, IN OHIO.

Mr. J. Warren Smith gives in his Climate and Crop report for June some account of the interesting destructive frost on the morning of June 30, in Ohio. He says:

> The interesting features in connection with this frost are its severity so late in the season and the limited area affected. A strong wind prevailed over most of the State, but there must have been wind-breaks sufficient to produce a calm over this great level district known as the Scioto Marsh. Under the clear sky the surface of the ground and of the plants lost heat rapidly by radiation, and in turn cooled the still air in contact with them, until just at the surface of the earth the temperature fell to the freezing point. The stratum of cold air must have been very thin, as the lowest temperature recorded by our voluntary observer at Kenton was 46°. His thermometers were not over six feet above the surface of the ground. We believe that if a large number of small or a few large fires had been built in different parts of the marsh a mixing of the air would have been produced sufficient to prevent formation of frost conditions.

The frost seems to have covered Hardin County and the neighboring portions of Allen, Hancock, and Marion counties. The morning map of Friday, June 30, shows that an area of high pressure was, at 8 a. m., central 100 miles northwest of this region, and the winds at Toledo and Columbus were northerly, with a velocity of 5 or 6 miles per hour. The special frost area seems to the Editor to represent not merely a region where cool air was formed by radiation and settled quietly to the ground, nor yet simply a region where the leaves of the plants cooled by radiation because the sky was clear. We have already explained in the MONTHLY WEATHER REVIEW, Vol. XXIV, p. 14, and in our "Preparatory Studies," Report of the Chief Signal Officer, 1889, p. 34, that in the middle of an area of high pressure, masses of air that are already specially cooled are descending to the ground and spreading out horizontally, forming spots of low temperature quite analogous to the inverse phenomenon, when special masses of warm moist air rise high enough to dot the sky with clouds here and there. We are inclined to think this third consideration is important and that such a mass of cold air descended upon northwestern Ohio and spread a little outward in all directions. Similar masses were descending by day and by night throughout the central high pressure area but only a few could produce destructive frost. Any one may see a similar phenomenon on a clear, warm, summer day when, in the midst of a calm period, the dust and leaves are suddenly observed to be blowing in all directions away from a central spot, and one must perceive at once that there has been a rapid descent of a small mass of denser air (it may have been drier or it may have been cooler), which, on reaching the ground, spreads outward and carries with it the dust and leaves.

CHALK-PLATE MAPS.

Not long since we had occasion to praise the excellent appearance of the maps published by the chalk plate process in the various monthly reports of the Climate and Crop Service, among which those published for Virginia particularly deserved commendation. The maps in the various reports for the month of June, 1899, showed many excellent features. We particularly wish to commend the pleasing effect of the green base and red isotherms in the New England report. The very clear print of the corresponding map in the Wisconsin report, and that for Ohio which is almost equally impressive. The black base map with red lines or the blue base with red lines seem to be the favorites, but the golden base with black lines and the green base with red lines strike us as being harmonious combinations that are also well worthy of trial. The Editor will be glad to hear from those experienced in these matters as to the relative advantages and difficulties in connection with different colored inks and qualities of paper.

TORNADO PHENOMENA.

Low Pressure.—The tornado that passed through New Richmond, Wis., on June 12, is quite fully described in the report of that section for June by Mr. W. M. Wilson, Section Director. Its path was from the southwest to the northeast, and it destroyed nearly the whole of the business portion of the town. Illustrations of the force of the wind are abundant, especially the fact that a large iron safe weighing 3,000 pounds was caught up and carried several hundred feet (possibly it was carried by the flooring on which it stood). Everywhere was to be seen convincing proof that the sudden lowering of atmospheric pressure over a small area was often the primary cause of destruction. Of course, there is no record of the